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Defense Economy of the United States Industrial Capacity

BY J. C. deWILDE and GEORGE MONSON

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Defense Economy of the United States: Industrial Capacity

BY J. C. deWILDE *and* GEORGE MONSON*

This is the third in a series of studies on the economic aspects of national defense. The first two were: "Defense Economy of the United States: Problems of Mobilization" (FOREIGN POLICY REPORTS, *November 1, 1940*); *the second, "Defense Economy of the United States: An Inventory of Raw Materials"* (FOREIGN POLICY REPORTS, *November 15, 1940*). *Subsequent issues will deal with labor, power, transportation and methods of financing the defense program.*

IN SOME respects the United States is well equipped to become the "arsenal of democracy." This country has led the entire world in the application of techniques of mass production. Its industrial development has been rapid and diversified,[1] and its general capacity to produce compares favorably with that of the totalitarian powers.[2] In other respects, however, the United States labors under certain disadvantages. In sharp contrast to many other countries, industrial progress has tended to stagnate during the last decade.[3] Investment in new plant and equipment has lagged, so that in many branches of industry much of the machinery is obsolescent.[4] Of still greater importance is the fact that American industry has been less adapted to the production of arms than that of almost any other modern nation. With the exception of a few government arsenals and shipyards,[5] which can satisfy only a small part of wartime requirements, the United States has had virtually no munitions industry since the first World War. Although American factories, with existing equipment, can supply most of the materials which go into the manufacture of implements of war, their capacity for turning out the finished product has been extremely limited. The mass-production industries cannot be simply converted to the manufacture of munitions. Their machinery is for the most part highly specialized, designed for the wholesale manufacture of a single product and hardly suitable for other purposes without extensive changes. With the annual model change in an automobile plant, for example, much of the machinery on the production lines must be scrapped or rebuilt.

These factors have necessitated the creation of an entirely new munitions industry. In general, the manufacturing facilities now being established are of four types:

1. *Permanent government-owned plants, operated by private management.* Such facilities are being provided particularly for the production of explosives, ammunition, small arms, guns, tanks, armor plate and other products which have no peacetime uses or counterpart. After the emergency they will be retained by the government as "standby capacity." Up to the end of January 1941 the War and Navy Departments had entered into contracts for new government plants and equipment amounting to about $650,000,000.[6]

2. *Plants and machinery financed and owned by the Defense Plant Corporation, a subsidiary of the RFC.* Facilities provided in this way are leased to pri-

*Mr. Monson is a consulting economist.

1. During the period 1899 to 1937 the manufacturing output of this country rose no less than 270 per cent. Solomon Fabricant, *The Output of Manufacturing Industries, 1899-1937* (New York, National Bureau of Economic Research, 1940), pp. 60-61.

2. According to a German study, the United States had 44 per cent of the world's industrial capacity in 1935, Britain 10 per cent, France 7 per cent, and the four totalitarian powers, including the U.S.S.R., a total of 29 per cent. Institut für Konjunkturforschung, *Industrielle Mobilmachung* (Hamburg, 1936), p. 76.

3. The physical output of American manufactures in 1937—the best year before the outbreak of the war—was only 3 per cent above the 1929 total. The output of the durable goods (including capital goods) industries was 16 per cent higher in the five-year period 1925-29 than in 1935-39. *Federal Reserve Bulletin,* December 1940, p. 1307.

4. In 1940 about 70 per cent of all the metal-working equipment employed in American industry was over 10 years old, as compared with only 44 per cent in 1925. *1940 Inventory of Metal-Working Equipment,* Supplement to *American Machinist,* May 29, 1940.

5. The army has six arsenals manufacturing guns, small arms, tanks, ammunition and explosives, as well as one depot which makes uniforms. The navy operates eight yards for the repair and construction of warships, one large gun factory, a small aircraft plant, a torpedo-manufacturing station, a mine depot, and a powder plant. It also owns an ordnance plant at South Charleston, W. Va., which is leased to the Carnegie-Illinois Steel Corporation for the manufacture of armor plate.

6. This total has been compiled from the Press Releases of the National Defense Advisory Commission.

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vate manufacturers for the production of munitions. Upon termination of the lease, the corporation will either transfer title to the War or Navy Department, or sell the plant to the manufacturer at cost less agreed depreciation, or at a lower negotiated price. By the middle of January 1941 the corporation had made commitments aggregating $349,779,683, of which $283,206,197 was for the construction and equipment of plants to manufacture planes and parts.[7]

3. Privately financed facilities, with gradual government reimbursement of cost. This type of expansion has been carried out under the so-called Emergency Plant Facilities Contract, by which the government agrees to reimburse the contractor for buildings or new machinery needed for defense work in a series of monthly payments extending over five years. On the basis of this promise, the contractor can obtain credit from banks or the RFC. At the end of five years, the government takes title to the property, although the operator may buy it at a negotiated price, or at cost less depreciation at a pre-arranged rate. By the end of January 1941 plant facilities contracts amounting to about $100,000,000 had been awarded, particularly to finance expansion in the aircraft and shipbuilding industries.

4. Privately owned plants and equipment. In general, private enterprise has been reluctant to provide at its own risk additional production facilities which might be used only during a comparatively brief emergency period. The Second Revenue Act of 1940, approved on October 9, 1940,[8] minimizes this risk to some extent by allowing corporations which add to their plant and equipment for defense purposes to amortize the cost out of tax-free earnings over a five-year period. The Act does not, of course, guarantee that profits will be large enough to take care of the extra depreciation allowances.[9]

In addition to this planned expansion of the country's industrial capacity, the government has had to adopt a number of measures to insure maximum utilization of industrial resources already available. A system of voluntary priorities has been instituted in order to give defense orders precedence over less essential work. Official and non-official efforts have been made to canvass idle plant and machinery which might be mobilized for the rearmament program; and steps have been taken to distribute defense work more evenly, through adoption of new government purchasing policies and encouragement of extensive subcontracting.

The degree of success with which industrial mobilization has been carried out and the problems that still require solution can be most readily appreciated by analyzing the present condition of the country's basic industries. Since it would be impossible to consider in a single FOREIGN POLICY REPORT all the industries important to national defense, this study will treat only those which are regarded as most essential to the defense program —namely, the iron and steel, machine tool, aircraft and automotive, shipbuilding and chemical industries.

THE IRON AND STEEL INDUSTRY

Steel is the basic metal in our industrial civilization and the lifeblood of defense. The fact that the iron and steel industry has already been operating virtually at capacity has caused a flood of speculation concerning its ability to meet future needs. Today annual steel capacity, in terms of ingots and castings (raw steel), is rated at 84,152,000 net tons;[9a] and on completion of current expansion and modernization projects, it should reach about 87,000,000 net tons early in 1942.[10] A reserve margin exists, however, because capacity figures make an allowance of 10 to 12.5 per cent for periodic relining of furnaces, breakdowns, and other maintenance requirements. In emergencies, therefore, it is possible to push operations at least 2.5 per cent above rated capacity, adding 2,100,000 tons to the present annual output. Since the industry has spent $1,500,000,000 on new facilities and improvements within the last decade, its physical condition is such that an operating rate in excess of 100 per cent could be sustained for a rather long period.

Capacity steel operation is predicated, however, on the ready availability of pig iron and scrap. Modern steel-making utilizes a large amount of scrap, as well as pig iron, the product of blast furnaces. Since fewer blast furnaces have been required to produce a given tonnage of steel, pig iron capacity has continued to decline in relation to steel capacity ever since 1923.[10a] If scrap should become less plentiful,[11] the real "choke point" in steel making would be the limited capacity of blast furnaces to supply pig iron, and of coke ovens to furnish the coke needed to smelt iron ore. Already there is but a small reserve margin.[12]

7. "Report to the President and the Congress of the United States," *Federal Loan Agency Press Release 76*, January 18, 1941.

8. *Public No. 801*, 76th Congress, 3d Session.

9. By the end of January 1941, 118 corporations had been accorded the special depreciation privileges of the Act for new facilities costing over $192,052,000. *The New York Times*, February 10, 1941.

9a. American Iron and Steel Institute, *Press Release*, January 31, 1941. Present capacity is almost 40 per cent higher than at the end of 1918, and 15 per cent larger than at the end of 1929.

10. *The New York Times*, February 7, 1941.

10a. The proportion of pig iron to steel capacity fell from 78 per cent in 1929 to 66 per cent in 1940, and will probably drop to 65 per cent in 1941. *The Iron Age*, January 2, 1941, p. 69.

11. For a discussion of the possibility of a scrap shortage, cf. J. C. deWilde and George Monson, "Defense Economy of the U.S.: An Inventory of Raw Materials," *Foreign Policy Reports*, November 15, 1940.

12. On December 1, 1940 only 27 of the 228 blast furnaces in the country were inactive; of these, 5 were obsolete, and many of the remainder required extensive repairs before they could

STEEL REQUIREMENTS. The adequacy of present steel capacity can be measured only against probable future requirements for export, the defense program and civilian consumption. In 1940 the United States exported about 8,056,000 net tons of semi-finished and finished steel, or more than 17 per cent of the tonnage produced for sale. Of this amount, some 54 per cent went to Britain and Canada. Britain's steel-making capacity of 15,700,000 net tons[13] is inadequate to sustain its war effort, and the United States is the only country capable of making up the deficiency. Export requirements during 1941 have been estimated at 10,000,000 net tons of finished steel (equivalent to about 12,000,000 tons of ingots or raw steel). Although Britain theoretically requires much more steel to attain equality with Germany, which now controls a capacity of about 42,000,000 tons, its actual purchases must be adjusted to the limited number of ships available to carry the steel.

It is extremely difficult to forecast the amount of steel needed in the defense program. Vessels now on order will consume about 3,500,000 net tons of finished steel (5,000,000 tons of ingots) over a period of four years.[14] The annual steel requirements for shipbuilding, including those for shipways and shipyards, will probably not exceed 2,000,000 tons. Aircraft and tank construction will, at most, consume 500,000 tons each, but not in any one year.[15] The other items in the armament program—guns, artillery ammunition, trucks, etc.—will put additional demands on the steel supply. One government expert has estimated that direct army and navy needs will absorb about 4,500,000 tons during the twelve months ending July 1, 1942; and W. S. Tower, president of the American Iron and Steel Institute, has put the peak of defense demand, including needs for plants, hangars and cantonments, etc., at 8,000,000 net tons of raw steel per year.[16] These estimates will have to be increased substantially if the United States becomes actively engaged in war, or if the government adopts the suggestion that the present armament program be increased to provide equipment for an army of 4,000,000, instead of 2,000,000 men. At the same time it must be remembered that mere expansion of the current program will not necessarily increase annual steel requirements unless the munitions industries increase manufacturing capacity rapidly enough to demand more steel.

At any rate, it appears unlikely that export and defense requirements in the near future will absorb over 20 million of the 84-million-ton capacity of the steel industry. The real question, therefore, is whether the remaining capacity will be adequate for normal or civilian needs. In the past, the peaks of steel consumption by industrial groups have fallen in 1929 or 1937. By taking the highest figure attained by each group in either of these two years, it is possible to estimate total aggregate requirements for civilian use at a theoretical maximum of 60,061,332 net tons of raw steel per year.[17] If consumption again reaches the per capita peak of 950 pounds of raw steel attained in 1929, civilian requirements would be a little greater—namely about 62,000,000 tons. Total annual demand based on the maximum estimates in each case would, therefore, compare as follows with steel capacity:

Requirements	*Ingots or Raw Steel (net tons)*
Exports	12,000,000
Defense	8,000,000
Civilian	62,000,000
Total	82,000,000
Rated Capacity	
End 1940	84,152,000
Early 1942	87,000,000
Present maximum working capacity	86,250,000

Steel-making facilities thus appear capable of meeting the potential demand, but with only a small margin. If consumption is left free to develop in the wake of "armament prosperity," the industry may be unable to satisfy steel requirements for more automobiles, more houses and more industrial equipment.

ALLOY STEEL—A BOTTLENECK? Despite the large over-all capacity of the steel industry, doubt has been expressed that it can produce in sufficient quantities the kinds of steel needed for armament. It is probable that defense requirements will be about equally divided between ordinary and alloy steel. Since only 3,211,955 net tons of alloy steel ingots and castings were produced in 1939, the de-

be put into operation. Thirteen of the idle blast furnaces belonged to the U.S. Steel Corporation. Cf. special survey conducted by *The Iron Age*, cited in *New York Herald Tribune*, December 8, 1940.

13. *The Iron Age* (January 2, 1941, p. 61) estimates that Britain produced 15,000,000 net tons of steel ingots and castings in 1940.

14. K. L. Austin, *The New York Times*, December 22, 1940. The 200 cargo vessels included in the emergency shipbuilding program launched by the President in January 1941 will demand an additional 600,000 tons over two years. *The Iron Age*, January 30, 1941, p. 85.

15. K. L. Austin, *The New York Times*, December 22, 1940.

16. American Iron and Steel Institute, *Press Release*, October 11, 1940.

17. The data for 1929 have been taken from *The Iron Trade Review*, January 2, 1930, p. 36, and for 1937 from *Steel*, March 14, 1938, p. 23. The 1929 figures have been adjusted for non-reporting companies and other factors, while finished and semi-finished steel tonnage has been converted into raw steel tonnage on the basis of 75:100.

fense program places a disproportionately heavy burden on the industry's alloy steel capacity. Steel of the finest type is needed for aircraft, engine valves, bearings, magnets and the tools required in the manufacture of arms. And the steel for ordnance must satisfy high standards of elasticity (gun steel), hardness and ability to withstand shock (armor plate, projectiles), toughness and ductility—all qualities which only specially treated alloy steels can supply.

The open-hearth furnaces, which produce about 90 per cent of all the steel in the United States, can undoubtedly produce a large part of the alloy steel needed, especially for ordnance.[18] In general, however, the open-hearth furnace can make only the low-alloy steels, used in substantial quantities by the automobile industry. The finest alloys, including particularly high-speed tool steels and the stainless steel needed for aircraft, are produced exclusively in electric furnaces, which also turn out a cleaner and denser product.[19] In order to forestall a possible bottleneck, the steel industry is in the process of increasing its electric furnace capacity from 1,900,000 to 2,800,000 tons per year.[20] The demand for fine steels is such, however, that further expansion may have to be undertaken.

Attention must be paid not only to raw steel capacity, but to capacity for shaping steel and improving its quality so as to meet manifold requirements. Steel is shaped by three methods of applying pressure—rolling, hammering and pressing—and by casting it into molds. Most steel products are rolled. Since 1927 rolling capacity has been greatly extended by widespread installation of the so-called continuous strip-sheet mills, which take the steel ingot and convert it by one continuous process into a finished product. While these mills can roll the types of plates used in the construction of destroyers, light tanks, scout cars and trucks, they are of little use in satisfying the demand for heavy products occasioned by the armament program. The mills which can meet such requirements have been severely taxed. At present, for example, some difficulty is experienced in making prompt deliveries of steel for construction, the first industry to reflect the steel needs of the defense program. Although orders for fabricated structural material rose to about 1,700,000 tons during 1940,[21] the bottleneck has been due more to the concentration of orders within a relatively brief period, than to the inadequacy of structural rolling capacity, which is 5,062,850 gross tons per year.[22] There are also current shortages of bars and the wide plates required for shipbuilding.

Forgings. There is such a decided shortage in the country's forging capacity that the Defense Commission, in September 1940, announced a $40,000,000 program to expand heavy forging facilities.[23] In forging, steel is shaped and kneaded through the application of tremendous pressure by huge hammers and presses which impart beneficial structural qualities to the metal. The products of this process are called forgings. The defense program has increased the demand for forgings of all types enormously. Shells, for example, are normally forged on machines in which a steel billet is pierced by a punch die driven by a press. While efficient modern shell-forging machines have been developed,[24] comparatively little of this equipment is yet available for large-scale production of shells. The building program required for the 70 per cent increase in the navy authorized in July 1940 demands an extraordinary increase in facilities to forge propeller and engine shaftings, rudder posts, turbine parts, guns, large armor-piercing projectiles, and armor plate.[25] While light armor plate is rolled,[26] heavier plate—ranging from 3 to 20 inches in thickness—must be forged; and only three companies—Bethlehem, Midvale, and Car-

18. In 1939 open-hearth furnaces accounted for 2,302,273 net tons of alloy steel, while electric furnaces contributed 749,384. The remainder of the 3,211,955-ton total was produced in Bessemer and crucible furnaces. American Iron and Steel Institute, *Annual Statistical Report 1939*, p. 19.

19. The following alloys are produced almost exclusively in electric furnaces: stainless steel, containing 11 to 14 per cent chromium; corrosion- and heat-resisting steels, containing 17 to 26 per cent chromium and 8 to 13 per cent nickel; special alloys for machines, instruments and apparatus of various kinds; alloy and carbon tool steels, including high-speed tool steels; magnet steel; and manganese steel containing 12 to 14 per cent manganese. J. M. Camp and C. B. Francis, *The Making, Shaping and Treating of Steel* (5th ed.: U.S. Steel Corporation, 1940), p. 499.

20. American Iron and Steel Institute, *Steel Facts*, December 1940, p. 1.

21. *Steel* (Cleveland), January 6, 1941, p. 376.

22. American Iron and Steel Institute, *Directory of the Iron and Steel Works of the United States and Canada, 1938*, p. 427.

23. National Defense Advisory Commission, *Press Release 96*, September 11, 1940.

24. For a description of various types of shell-forging machines, cf. *The Iron Age*, October 10, 1940, p. 57, and October 24, 1940, p. 41; also *American Machinist*, December 25, 1940. In the absence of sufficient forging equipment, it may prove possible to make shells from seamless tubing, which the steel industry can turn out in large quantities. The army's Frankford Arsenal has developed such a process. Lt. Col. L. H. Campbell, Jr., "Artillery Ammunition Production," *Army Ordnance* (Washington), March-April 1939.

25. In one item alone—gun forgings for the navy—undelivered orders in July 1940 amounted to 29,000,000 pounds; and it was anticipated that 59,000,000 pounds more would be required for the 70 per cent expansion of the fleet. Testimony of Rear Admiral W. R. Furlong, Chief, Bureau of Ordnance, July 22, 1940. *Hearings before the Subcommittee of the Committee on Appropriations, House of Representatives, 76th Congress, 3d Session, on the Second Supplemental National Defense Appropriation Bill for 1941*, pp. 60-61.

26. It should be noted, however, that facilities for fabricating and treating various types of light armor are still inadequate.

negie-Illinois—have the requisite experience and equipment to make it. The Navy Department's Bureau of Ordnance is spending large sums to expand the equipment and plant of the nation's most efficient forging companies. The Carnegie-Illinois Steel Corporation alone has received $50,353,000 in contracts to increase the facilities of the naval ordnance plant at Charleston, W. Va., for the making of armor plate. It takes from eight months to a year, however, to secure delivery of the heavy hammers and presses needed for forging.

The bottleneck in forgings might be partly eliminated by increased use of castings. Casting techniques have improved so greatly that many of the qualities which made castings unsuitable for ordnance have been overcome. Already seven foundries are turning out cast-steel turrets and hulls for tanks, and a number are making cast-steel shells.[27] A new method of gun construction by centrifugal casting has also been developed and might be used to accelerate production.[28] Castings, however, require extensive heat-treatment, and their use is necessarily limited by the availability of heat-treatment furnaces.

There is, in fact, a serious shortage of heat-treating facilities. In the production of steels for ordnance, repeated heat-treatment is necessary to create such qualities as exceptional hardness, resistance to shock, elasticity and strength. Heavy armor, for example, requires a series of heat-treating operations for which time, skill, and large, modern furnaces are needed.[29] In the last two decades such rapid advances have been made in equipment and technique that many furnaces in the industry have become obsolete. Industrial furnace manufacturers are now overwhelmed with orders.[30]

THE NEED FOR EXPANSION. Analysis of the steel and related industries reveals certain actual and potential bottlenecks which can be overcome only by expansion of plant and equipment. This is true in the case of forging, heat-treating and armor-plate facilities. A further increase in the capacity of electric furnaces for the production of fine alloy steels also appears necessary. There is considerable controversy, however, about the need for general expansion in the steel industry, particularly of ingot capacity. The dispute hinges largely on the question whether this country wishes to satisfy unlimited civilian as well as defense needs. A number of government economists definitely favor expansion to take care of all conceivable requirements. In a study published in June 1940, the National Resources Planning Board[31] suggested that the steel industry might have to increase its capacity 15 to 40 million gross tons to meet requirements arising from the anticipated increase in national income.

Steel manufacturers, however, fear that large-scale expansion may ultimately burden the industry with excess capacity. During the past 22 years available capacity has been utilized on an average of only 61 per cent.[32] Less than two years ago, one government agency accused the industry of trying to maintain too much excess plant and equipment, and demanded that part of it be scrapped.[33] The industry also claims that expansion would entail additional demands for certain raw materials and types of electrical equipment which are already difficult to obtain.[33a] While the steel companies are willing to undertake a moderate expansion program,[34] they prefer that nonessential consumption be curtailed wherever necessary. By rationing the supply of steel for passenger automobiles, refrigerators, containers and furnishings, a considerable tonnage might be released for more important uses.[35]

Irrespective of the controversy about expansion and rationing, certain steps might be taken to insure more complete and efficient utilization of all available capacity. Orders might be redistributed so that no one company would have idle facilities

27. *The Foundry* (Cleveland), November 1940, p. 33.

28. Col. N. F. Ramsey, *The Foundry*, April 1940, p. 29.

29. D. K. Bullens, *Steel and Its Heat-Treatment* (4th ed.: New York, J. Wiley & Sons, 1938), p. 275.

30. The Industrial Furnace Manufacturers Association has claimed that it can cope with orders, provided not too many departures from standardized designs are demanded and delivery schedules are adjusted to real needs. *Business Week*, December 7, 1940, p. 46.

31. *Capital Requirements: A Study of Methods as Applied to the Iron and Steel Industry*, p. 34. This study makes several errors in gauging expansion requirements. It estimates the present "practical" capacity of the steel industry by deducting 10.7 per cent from "rated" capacity, even though the latter already makes a liberal allowance for maintenance and repair of furnaces, etc.; and it derives future demand from the anticipated rise in "consumer income," despite the fact that industrial profits exert a much greater influence on the development of steel demand.

32. *The Iron Age*, January 2, 1941, p. 69.

33. The Federal Trade Commission, *Monopoly and Competition in Steel* (released March 7, 1939), pp. 4, 6, 11.

33a. New furnaces and mills would have to be located in or near existing steel centers, because the cost of assembling raw materials elsewhere would be prohibitive and all units of the iron and steel industry must be in close proximity to each other. The burden would therefore fall on heavily industrialized areas where available resources are already being increasingly taxed by the defense program.

34. The iron and steel industry plans to spend more than $282,000,000 for new equipment during 1941. The program will provide additional coke, pig iron and steel capacity, as well as equipment for many varieties of rolled and finished steel. American Iron and Steel Institute, *Press Release*, January 24, 1941.

35. In 1937 the automobile industry took 21.4 per cent of the total steel shipped, the tin can and container industry, 8 per cent, and furnishings and furniture, 3.4 per cent. U.S. Steel Corporation, *T.N.E.C. Papers*, Vol. I, p. 328.

while another is overburdened.[35a] Simplification and standardization of steel products, of which there is a bewildering number,[36] would probably speed up production. A thoroughgoing application of priorities is also necessary, particularly to eliminate extensive buying based on fear of possible shortages, rather than on real needs in the near future.

THE MACHINE TOOL INDUSTRY

Next to iron and steel, the machine tool industry is most essential to national defense. Machine tools are the power-driven machines which do for metal what the saw, chisel, plane, file and hammer do for wood. They cut or shape metal by a variety of operations which might be roughly classified as milling, planing, turning, boring and grinding. Machine tools may cut off large chunks of metal or, as in the case of grinding and honing, chip off particles which can be seen only under the microscope. They range from the simple bench lathe to the complicated Keller automatic tool-room machine, which traces the contours of a master die while a cutting tool simultaneously carves out an exact replica of the model in hard steel. There are the all-purpose machine tools, which can be adapted to almost any task and are used to make machines and turn out products in relatively small quantities; and the specialized or single-purpose machine tools, which are designed to perform a series of rapid automatic operations, but must be rebuilt or replaced every time there is a change in specifications.[37]

Without machine tools our mechanized civilization would be impossible. They enable factories and plants to turn out the interchangeable parts on which mass production depends. And the machine tool industry itself is the only one which can reproduce its products. The industry, which consists of only a few hundred small and medium-sized establishments, staffed by highly skilled engineers and workmen, has always fluctuated widely in accordance with new investments in plant and equipment. During the first World War its output soared from $50,000,000 in 1914 to $500,000,000 in 1918, only to suffer a sharp decline afterwards. By 1929 the value of the industry's products had risen to $244,578,000, but in 1933 it hit a low of $41,433,000.[38] Subsequently the rearmament drive abroad, followed by the war, aided materially in its recovery. In 1940 the defense program of the United States imposed new and far-reaching demands on the industry. Although output has more than doubled, attaining $450,000,000, it must reach between $600,000,000 and $700,000,000 this year if defense requirements are to be met.

MAJOR BOTTLENECK. Under these conditions, the machine tool industry has become a bottleneck in the defense program. Numerous plants which are being erected or expanded must procure the necessary machinery before munitions can be produced on a large scale.[39] The industry has tried hard to cope with these requirements, which were augmented by a continuous stream of orders from England, Canada and, until June 1940, France. Plants have been expanded, working hours increased, and a large part of the work subcontracted or "farmed out." Although the instability of the industry has created an understandable aversion to extensive increases in capacity, many machine tool companies have added to their plants and equipment.[40] In the last two years, the industry has more than doubled the number of employees and done much to train inexperienced workers. Most firms are operating on a two- and three-shift basis, and others are working 50 hours or more a week. Subcontracting has perhaps made the greatest contribution to the increase in output.[41] In some cases whole orders have been "farmed out" to other industries. The Westinghouse Electric and Manufacturing Company, for example, has been making milling machines, and a number of printing and textile machinery concerns have also taken over orders for entire machine tools.

Despite these efforts and the curtailment of exports to non-British countries, the British and American demand for machine tools remains far

35a. Philip Murray, president of the C.I.O., has recently proposed that the whole industry be treated as a single production unit, with complete coordination of all melting and finishing facilities. *The New York Times*, January 22, 1941.

36. There are more than 4,200 sizes and shapes of steel products and nearly 600 types of alloys in use today. *New York Herald Tribune*, January 19, 1941.

37. For a description of machine tools, cf. W. P. Turner, *Machine Tool Work* (New York, McGraw-Hill, 1932), and H. D. Burghardt, *Machine Tool Operation* (2 vols.: New York, McGraw-Hill, 1936-37).

38. David Longanecker, "Machine Tools—Indispensable in Peace or War," *Domestic Commerce Bulletin*, September 19, 1940. Census figures for 1939 disclosed that the industry (exclusive of plants manufacturing accessories) had 200 plants, employing 8,220 salaried personnel and 36,624 wage-earners, and turned out products valued at $218,044,728. *The New York Times*, September 26, 1940.

39. An indication of the magnitude of the demand for new tools can be gleaned from the fact that General Motors, Ford, Chrysler and Packard need $100,000,000 worth of equipment for the manufacture of machine guns, Pratt & Whitney engines, tanks and Rolls Royce plane engines, respectively. *American Machinist*, October 30, 1940, p. 892b.

40. Sixty-five out of 115 companies recently surveyed reported plant extensions between August 1939 and September 1940, adding in most cases about 30 per cent to existing manufacturing area. *Machine Tool Expansion and National Defense* (Cleveland, National Machine Tool Builders Association, December 1940).

41. A survey of 115 companies toward the end of 1940 revealed that 80 of them had placed subcontracts for parts, 33 for sub-assemblies and 23 for entire machines. *Ibid.*

from satisfied. On December 9, 1940 Mr. Knudsen addressed an urgent appeal to machine tool builders to speed up production and deliveries still further.[42] Among the steps which have recently been taken or proposed to relieve the situation are:

1. Formulation of a definite production program and delivery schedules based on actual needs. The industry complains that it has been handicapped by the government's failure to give adequate information about future requirements, on which a definite production plan could be based.[43] The administration of voluntary priorities has also caused severe criticism because virtually all defense orders have received the highest preference rating without discrimination between varying degrees of urgency and actual delivery requirements. It has therefore been suggested that manufacturers, machine tool builders and government officials cooperate in drawing up a staggered delivery schedule more in accordance with real needs.[44] Some steps are being taken in this direction.

2. Expansion of existing plant with government assistance. In a rather belated attempt to break the "bottleneck," the War Department on December 17, 1940 announced that three machine tool companies would receive contracts for expansion of production facilities and that similar action would be taken with respect to other concerns.[45]

3. Encouragement of still more subcontracting. In some quarters belief is expressed that the industry could go much farther, both in subcontracting parts and in farming out construction of the simpler types of machine tools to other industries.

4. Employment and training of additional personnel. The shortage of skilled tool engineers, foremen and mechanics is difficult to overcome. Training programs will have to be intensified, and the government may be called upon to assist in transferring tool workers to communities where their services are in demand.[46]

5. Utilization of the many machine tools still idle in small shops and factories. Sample surveys, particularly those conducted in depressed industrial areas, have revealed that many existing machine tools are idle for lack of orders.[47] If these tools were fully utilized for defense work, the need for new machinery might be substantially reduced. In some communities the idle capacity in small plants and shops has already been pooled in the hope of obtaining joint contracts.

6. Prohibition of all exports to Japan and the Soviet Union. As yet there is no embargo on such shipments. Exports of all machine tools were originally subjected to license by the President's proclamation of July 2, 1940, but subsequently many exemptions were made. Beginning December 10, 1940, the licensing system was extended to include a large number of additional types of machine tools and accessories.[48] While combined exports to Japan and the Soviet Union during October-November 1940 were valued at $3,027,249, the bulk of these shipments probably consisted of tools not urgently needed by the United States or Britain.[49]

7. Complete concentration on national defense orders, whether for the United States, Britain or Canada. Virtually all the industry's work is already directly or indirectly related to defense.[50] Mr. Knudsen notified the automobile industry on October 15, 1940 not to expect a "lot of machine tools";[51] and changes in 1941 automobile models will be kept so slight that few new tools will be needed. On January 31, 1941 Mr. Stettinius, Director of the Division of Priorities, formally requested that no machine tools be delivered after February 28 unless the order had obtained a priority rating.[51a]

8. Production of single-purpose machines. The National Machine Tool Builders Association has cooperated in the development of single-purpose machines which might be built by concerns outside the industry and used to speed up production of munitions. For example, two lines of shell-machining equipment have been designed: one, very simple, which could be produced in large quantities; the other, a complicated multi-tooled lathe, which can turn out one 75-mm. shell a minute. Although a few of these machines have been built and tested with excellent results, they are not yet being made on any considerable scale.[52]

Elimination of the machine tool bottleneck would in itself be of limited value unless the gauge-making capacity of the country were increased substantially. No work of precision can be turned out on machine tools without a large variety of measuring instruments. In American industry there are almost as many types of gauges as there are operations. They range from relatively simple micrometers for ordinary inspection jobs

42. *The New York Times,* December 17, 1940.

43. Statement of Clayton R. Burt, president of the National Machine Tool Builders Association, *The Wall Street Journal,* December 24, 1940; also Alsop and Kintner, *New York Herald Tribune,* December 22, 1940.

44. Statement of Charles J. Stillwell, president of Warner & Swasey Company, *The New York Times,* January 2, 1940.

45. *Ibid.,* December 18, 1940.

46. The labor aspects of the national defense program will be considered in a subsequent issue of *Foreign Policy Reports.*

47. Speech by Morris L. Cooke, Consultant on Management Engineering on the staff of Sidney Hillman. National Defense Advisory Commission, *Press Release 344,* January 9, 1941.

48. *The New York Times,* December 5, 1940.

49. In the first 11 months of 1940 machine tool shipments to Japan amounted to $16,386,008, and those to the Soviet Union to $13,861,208.

50. One company has reported that its unfilled orders, as of October 14, 1940, were distributed as follows: United States navy, 6.42 per cent; United States army, 3.36 per cent; United States army air corps, 3.37 per cent; aviation industry, 25.1 per cent; national defense contractors, 27 per cent; England, Canada and other British dominions, 28.84 per cent; machine tool builders, 2.2 per cent; miscellaneous, 3.35 per cent. *Machine Tool Expansion for National Defense,* cited.

51. *The New York Times,* October 16, 1940.

51a. *Ibid.,* February 1, 1941.

52. *Machine Tool Expansion for National Defense,* cited; also *The Iron Age,* October 24, 1940, pp. 40-41. The Frankford Arsenal of the army is the only plant provided with modern, specialized shell-machining equipment. Any shop with standard lathes, however, could probably be adapted without much difficulty to the machining of shells.

to complicated electrolimit comparators which detect variations of one hundred thousandth of an inch, by means of an electrical current, and optical gauges which can measure a millionth of an inch with a light beam indicator.[53] The production of aircraft engines and ordnance, requiring extreme accuracy, demands a large supply of gauges. At present all gauge-makers, such as the Pratt & Whitney division of the Niles-Bement-Pond Company, are booked to capacity. It has been estimated that about $16,000,000 worth of gauges will be needed in the next two years, although the country's productive capacity is only $5,000,000 a year.[54] It was not until November 25, 1940 that the War Department announced its intention to award contracts totaling $3,500,000 to four companies for expansion of gauge-making facilities.[55] Output may be limited by the shortage of highly skilled craftsmen required for this task.

OPTICS AND DEFENSE

During the first World War the United States experienced a serious bottleneck not only in making gauges, but in producing the optical glass and instruments on which our armed forces depend. Today the army and navy again need considerable quantities of optical glass, range- and height-finders, gun and bomb sights, telescopes, binoculars, periscopes, drift meters, sextants, aerial mapping projectors, etc. Although only about half a dozen concerns employing over 100 persons are engaged in making such products,[56] the actual and potential supply is far greater than in the first World War.

Before 1914 this country imported all its optical glass, primarily from Germany. By dint of much effort and experimentation, we finally developed our own production, achieving an output of over 6,000,000 pounds between April 1917 and November 1918. The bulk was produced by the Bausch & Lomb Optical Company, the balance by the Pittsburgh Plate Glass Company, Spencer Lens Company, Keuffel & Esser and the U.S. Bureau of Standards. Although only Bausch & Lomb and the Bureau of Standards continued to produce after the war, a serious bottleneck in the supply of optical glass does not seem likely. The industry has mastered the technical problems of production, and the procurement of sufficient porcelain melting pots, which used to hamper output, is no longer difficult owing to improvements in potmaking.[57] Bausch & Lomb now makes 24 types of optical glass, as compared with 6 in 1917-18, and has enough equipment to turn out about 250,000 pounds a year. Its output could be doubled within a few months and is being supplemented by that of other companies. The Corning Glass Company is already producing small quantities; the Pittsburgh Plate Glass Company is building a small furnace; and the Spencer Lens Company may reopen the plant it operated in the last war.[58] Moreover, the army and navy have accumulated a considerable inventory of optical glass for emergencies.

The real bottleneck is in the grinding, polishing and inspection of lenses, and the assembly and adjustment of optical instruments. This requires workmen of great skill who must be trained from one to four years. The construction of range-finders is particularly difficult. A 40-foot range-finder contains 1,500 mechanical parts and 160 separate optical elements.[59] Only three companies manufacture these, and Bausch & Lomb alone makes the largest ones. The Department of Justice has accused Bausch & Lomb of using patents jointly controlled with Carl Zeiss, the German firm, to prevent other American companies from manufacturing military optical instruments.[60] No German interest, however, now has the power to restrict output in the United States. Production is limited only by the fact that so few companies possess the requisite technical experience and skilled personnel. In May 1940 Admiral W. R. Furlong testified that range-finders were so hard to obtain that the "whole program could not be met for seven years at present rates of production."[61] Since then the companies in question, particularly Bausch & Lomb and the Spencer Lens Company, have been expanding output. On the other hand, the decision to build a two-ocean navy has greatly increased requirements.

THE AIRCRAFT INDUSTRY

Until recently, the public was sanguine about the ability of American industry to manufacture planes. There was general confidence in the qual-

53. For a description of such gauges, cf. "Pratt & Whitney: Machine-Tool Maker," *Fortune*, April 1940.

54. *Business Week*, November 23, 1940, p. 16.

55. *The New York Times*, November 26, 1940.

56. Carl L. Bausch, "Optics and Defense," *Army Ordnance*, May-June 1940.

57. *Ibid.*

58. "Bausch and Lomb," *Fortune*, October 1940.

59. *Ibid.*

60. On March 27, 1940 a grand jury returned an indictment charging the company, three of its officers, Carl Zeiss of Jena, Germany, and Carl Zeiss of New York with conspiracy in restraint of trade. The suit was subsequently compromised, Bausch & Lomb and its officers submitting to fines of $40,000. *Ibid.*; cf. also Thurman W. Arnold, *The Bottlenecks of Business* (New York, Reynal & Hitchcock, 1940), pp. 69-71.

61. *Supplemental Hearings before the Subcommittee of the Committee on Appropriations, House of Representatives 76th Congress, 3d Session, on the Senate Amendments to the Navy Department Appropriation Bill for 1941*, p. 36.

ity and performance of American aircraft. Our commercial planes were being used by many of the world's leading air lines; and it was widely believed that American genius would find ways and means to match Germany's output of military craft. For this reason, public disappointment was keen and vocal when Mr. Knudsen revealed on December 13, 1940 that production was behind schedule. The output of 700 military planes in December—a figure later revised to 799—seemed far below the monthly rate of 2,000 to 3,000 which Germany was achieving according to most estimates.

The aircraft industry views its record more optimistically. A little over a year ago the demand for its products was still relatively light. In 1939 it turned out 2,141 military and 263 commercial planes—a total of 2,404; and in January 1940 its output was 351.[62] At the end of 1939 the industry as a whole was working at only 60 per cent of capacity.[63] Following repeal of the arms embargo in November 1939, France and Great Britain placed large orders; and after the outbreak of total war on the Western front, the United States army and navy, amply provided for the first time with funds by Congress, launched a tremendous air expansion program. To cope with this sudden increase in demand, the aircraft industry spent $83,356,580 during 1940 on plant expansion, and let contracts amounting to $232,188,472 for facilities expected to be in operation by the middle of 1941. Productive floor space was extended from 11,983,896 to 22,530,988 square feet, with 22,635,190 more under construction. Shop personnel rose from 60,000 to 164,920, and is expected to reach 382,000 by June 1941.[64] Although the expansion program for the most part will not bear fruit until the middle of 1941, the industry produced $544,440,000 worth of planes, engines and propellers during 1940, against $225,000,000 in 1939.[65] Output last year amounted to about 5,800 military aircraft.

Progress would undoubtedly have been greater if the government and the manufacturers had come to an earlier understanding. During the summer of 1940 plane contracts, and attendant expansion of manufacturing facilities, were held up for several months by the controversy over taxes, amortization and profits. There was also considerable delay in drawing up a long-range production program, owing in part to confusion over the respective responsibility of the Treasury, the Defense Commission and the army and navy. The goal of 50,000 planes a year, suggested by President Roosevelt in May 1940, was soon discarded. One expert estimated that to achieve such a goal productive floor space of plane, engine and propeller plants would have to be increased from 14,500,000 to 70,000,000 square feet which, together with offices, would entail an outlay of $572,000,000.[66] After considering British and American requirements, a more modest schedule was drawn up, calling for a monthly production of 1,250 planes by January 1, 1941, 1,500 by July 1, 1941 and 3,000 by the spring of 1942.[67] The industry was expected to turn out about 40,000 planes in the two-year period ending July 1942—some 14,000 for the British, and approximately 26,000 for our own army and navy.[68] In retrospect, this program appears over-optimistic.

Obstacles to Mass Production. For many reasons it has so far been impossible to apply to aircraft the mass-production technique used in the manufacture of automobiles. When Henry Ford announced in June 1940 that, after a period of preparation, he could make 1,000 planes a day, his offer was conditioned on standardization of aircraft, large and stable orders, and no changes in specifications in the course of manufacture. These are the conditions which prevail in the automobile industry. A new model is designed, then "frozen" for a year, and specialized, automatic machines are built to turn it out in large numbers. The annual retooling entails extremely heavy expenditure which can be borne only because the cost is distributed not over a few thousand cars, but over hundreds of thousands. Aircraft is undergoing such rapid changes in design, however, that standardization has not been achieved. While an automobile factory may turn out 2,000 units of one type of car a day, an aircraft plant would, even now, produce hardly more than 1,000 planes of a single type during an entire year. Altogether, the defense program includes about 45 models—even 50 if some special types being manufactured for the British are taken into consideration.[69] In Au-

62. *The Aircraft Yearbook for 1940*, p. 27. These totals, as elsewhere in this report, do not include planes produced for private, non-commercial use—which amounted to about 3,700 in 1939.

63. *Ibid.*, p. 28.

64. These figures, covering the manufacturers of principal accessories, as well as the manufacturers of engines, propellers and air frames, are taken from a statement by Col. John H. Jouett, president of the Aeronautical Chamber of Commerce, released to the press on December 5, 1940.

65. Aeronautical Chamber of Commerce, *Press Release*, January 28, 1941.

66. T. P. Wright, "50,000 Planes a Year," *Aviation*, July 1940. Mr. Wright also estimated that this production rate would require a personnel of 680,000.

67. Address by William S. Knudsen before the Army Ordnance Association, National Defense Advisory Commission, *Press Release 150*, October 8, 1940.

68. Hanson W. Baldwin, *The New York Times*, November 1, 1940.

69. T. P. Wright, "The Truth about Our National Defense Program," *Aviation*, January 1941.

gust Mr. Knudsen expressed the opinion that "too many factories are wasting their time on a lot of different types of planes."[70] Although the President appointed a four-man committee in October 1940 to coordinate design, the task of standardizing and reducing the number of models has apparently been deferred until 1942, in part because it would retard output while manufacturers were familiarizing themselves with the standardized types and getting them into production.[71] More recently it has been said that the diversified and special military uses of aircraft would probably make it necessary to retain at least 30 or 40 models.[72]

Even if it were possible to reduce the number of models, there would be no guarantee against the frequent changes in design and specifications which have greatly hampered output.[73] The airplane is undergoing more rapid technical evolution than the automobile. In the current war different types are constantly being tested in actual combat, so that both the British and our own air force officials are often impelled to ask manufacturers to incorporate new features in planes already on the production line. It would, of course, be possible to sacrifice progress in quality and performance to greater speed in production. In Germany, for example, the manufacture of planes has been standardized to a greater degree than in this country,[74] apparently at the expense of quality. United States army and navy officers, however, emphasize continuous improvement in design and maximum technical progress as the prime requisites.

Mass production is also difficult because exacting standards as to weight, performance and strength must be met in the construction of engines and frames. No plane could withstand the strain of flying and maneuvering at high speed unless great care had been taken to eliminate all structural weak points and to dovetail all engine parts with precision so that excessive vibration was eliminated. A single cylinder of a combat engine must develop well over 100 horsepower, while an 8-cylinder automobile engine has a total horsepower rating of only 100. The automobile motor may weigh five pounds per horsepower, the plane motor only a little over a pound. The airplane engine therefore requires more machining. Parts must be machine-finished and polished on all surfaces to an unusual degree.[75] Even the perspiration of a man's fingers can cause corrosion which, although invisible to the naked eye, may make the part useless.[76] Airplane engines are thus virtually tailor-made. Even the automobile manufacturers who have undertaken to build plane motors cannot turn out these engines with batteries of single-purpose, automatic machines similar to those employed in producing automobile motors, but are using the same methods as the aircraft industry. If mass-production technique is ever to be applied, engine designs will have to be fundamentally changed. Ford is experimenting with a motor of simpler design and fewer parts,[77] but he is expected to take a long time to develop such an engine and design the specialized machine tools needed to make it in large quantities.

One of the chief problems in the aircraft industry has been to synchronize the expansion of facilities which manufacture all the components of planes—engines, propellers, air frames and accessories—and the supply of such vital materials as aluminum, magnesium and steel alloys. Temporary or permanent bottlenecks develop unless production in all departments increases in just the right proportion. Actually, output has not progressed everywhere to the same degree, so that shortages have inevitably appeared.

THE ALUMINUM AND MAGNESIUM SHORTAGE. Some manufacturers are already experiencing difficulties in procuring aluminum, magnesium and steel alloys. Because of increasing civilian and military demand, a shortage of ingot or raw aluminum is already evident in a few cases. One of the leading fabricators has been unable to obtain a sufficient supply,[78] and rural electrification projects have been retarded to some extent by delays in deliveries of aluminum.[79] Monthly capacity at present is about 52 million pounds, and Defense Commission officials expect that expansion already under way and planned will lift production to 64.5 million by June 1941, and 76 million by June 1942. Meanwhile, however, the government may

70. *The New York Times,* August 24, 1940.

71. *Aviation,* November 1940, p. 85.

72. Wright, "The Truth about Our National Defense Program," cited.

73. According to a statement by P. G. Agnew, secretary of the American Standards Association, the Wright Aeronautical Company made more than a thousand changes in one of its Cyclone engines in 1938, while Pratt & Whitney made 750 alterations in a single plane engine model during 1939. *The New York Times,* January 2, 1941.

74. P. H. Wilkinson, "Warplane Factories in Germany," *Aviation,* September 1940.

75. A 1,700-horsepower, Wright double-row Cyclone engine, for example, consists of 5,500 separate parts, which require a total of 45,000 machine operations and 50,000 inspection steps.

76. *Automobile Facts,* December 1940, p. 2.

77. E. P. Flynn, *New York Post,* December 19, 1940.

78. The Reynolds Metals Company has notified Senator Joseph O'Mahoney that the Aluminum Company of America had promised delivery of less than half the aluminum requested for January 1941 and had given no assurances about supplies beyond that month. *The Christian Science Monitor,* January 15, 1941.

79. Letter of Harry Slattery, Rural Electrification Administrator, to Senator O'Mahoney, *ibid.*

have to take definite steps to curtail production for civilian uses, which still absorbs more than half the supply.[80]

A more serious bottleneck is the fabricating capacity for strong aluminum alloy sheet, extrusions, tubings, castings and forgings. There need be no supply problem with respect to sheets for plane fuselages, provided their use in buses and trains is reduced. Delays in deliveries of castings and forgings have been most frequently reported. In some cases these delays have been due to failure to place orders well in advance; in others, to a genuine, if perhaps temporary, shortage. The manufacture of more complicated castings and forgings is a difficult technical job which only a few companies, such as the Aluminum Company of America and the Reynolds Metals Company, have mastered.[81] These companies have hardly been able to keep up with the demand, which has risen with extraordinary rapidity because military planes, like bombers, require many more forgings than commercial transports. The Defense Commission has claimed that leading fabricators have undertaken expansion programs which will in the long run keep them well abreast of requirements.[82] It is said that at least one automobile company, Willys-Overland Motors Inc., may also undertake to make forgings. The expansion program may be delayed, however, if difficulties are encountered in procuring the necessary forge hammers, or skilled die makers and forge-hammer operators. The supply of castings, in which shortages have also been reported, might be increased if an intensive effort were made to educate foundries with idle capacity in making the simpler types. In December 1940 the Delco-Remy Division of General Motors completed, in the record time of 12 weeks, a modern foundry which will make aluminum castings for the Allison plane engine.

Although the Dow Chemical Company, the only producer of virgin magnesium, has just increased its annual capacity from 6,500 to 15,000 tons by opening a new plant at Freeport, Texas, fear has been expressed that even this amount will ultimately be insufficient to meet the rising demand for engines and fuselages, as well as tracer bullets and flares. Fabricating facilities, however, are being rapidly extended to eliminate a potential bottleneck. The leading fabricator, the American Magnesium Corporation, announced plans last October for tripling its output.[83] In December Ford started construction of a magnesium foundry, which will not only supply all the castings for the Pratt & Whitney plane engines it will manufacture, but have a surplus for sale.[84]

THE ENGINE BOTTLENECK. Engines have been, and for some time will continue to be, the most serious bottleneck in the production of aircraft.[85] When the defense program was launched early in the summer of 1940, engine plants were already working at 90 per cent of capacity, while manufacturers of air frames still had a considerable margin for expansion. Despite the steps taken to provide additional production facilities,[86] engine builders are still lagging behind. An average of two motors are needed for every plane. The shortage became so acute in December 1940 that commercial air lines had to release to the army a number of engines on hand and on order. Since the air lines have on order only 250 planes and a corresponding number of motors, invocation of priorities at their expense can hardly provide any permanent or substantial relief.[87]

The most important problem is to increase production of engines of 1,000 horsepower and over, which are required for combat planes. Only three companies build such engines at present — the Wright Aeronautical Corporation and United Aircraft (Pratt & Whitney), which make air-cooled motors, and General Motors (Allison Division), which manufactures a liquid-cooled engine. At the beginning of the year the first two were surpassing a monthly output of 1,000,000 horsepower each, while the third was reaching a total of 400,000 horsepower. All three have large expansion programs under way. After full equipment of its new addition, Allison plans to turn out 1,000 motors a month by the end of 1941.[88] Wright and United

80. Cf. summary of a report made by Marion B. Folsom to Edward R. Stettinius, *The New York Times*, January 17, 1941.

81. Cf. article by E. P. Flynn, *New York Post*, December 18, 1940.

82. In a statement issued on December 29, 1940 (National Defense Advisory Commission, *Press Release 330*) Mr. Stettinius claimed that: (1) forge-hammer capacity had increased 36 per cent in the last three months and was scheduled to rise by another 94 per cent during January and February 1941; (2) strong alloy sheet capacity, rated at 8,000,000 pounds a month, was expected to be 12,500,000 pounds in March 1941, 15,000,000 in August 1941, and 22,500,000 in June 1942; and (3) similar steps were under way to provide additional capacity for other fabricated items.

83. *The Iron Age*, October 17, 1940, p. 84.

84. *New York Herald Tribune*, December 29, 1940.

85. Rear Admiral John H. Towers, Chief of the Navy's Bureau of Aeronautics, testified before the House Naval Affairs Committee that "the shortage of engines will exist for another eighteen months." *Ibid.*, January 8, 1941.

86. According to a statement made on January 28, 1941, by Col. John H. Jouett, president of the Aeronautical Chamber of Commerce, engine builders expanded their productive floor space from 2,210,730 to 5,272,479 square feet during 1940, and will have 9,700,958 square feet available on completion of their present program.

87. *Aviation*, January 1941, p. 93.

88. For statement of Alfred P. Sloan, Jr., Chairman of the Board, General Motors Corporation, cf. *The New York Times*, December 12, 1940. Mr. Sloan announced that current monthly production amounted to 350.

Aircraft also expect to double present output by next fall. In December 1940 the Navy Department contracted with United Aircraft for additional facilities costing $14,799,000 at the Pratt & Whitney engine plant near Hartford, Conn.; and in January 1941 the government agreed to finance construction of a large engine factory for Wright near Cincinnati, Ohio.[89] The government is also assisting manufacturers of engine parts to expand their plants.

The supply of engines will become more plentiful as the automobile companies begin production of plane motors. Packard agreed last July to manufacture 9,000 liquid-cooled Rolls-Royce plane engines under British license—6,000 for the United States and 3,000 for Britain. In September 1940 Ford undertook to construct 4,000 Pratt & Whitney engines; and in January 1941 arrangements were made with Buick and Studebaker to build Pratt & Whitney and Wright motors respectively. In each case, however, construction and equipment of entirely new plants is involved, since little of the available automobile motor machinery is said to be suitable for manufacturing plane engines. Ford and Packard will not be ready for production before July or August 1941; and the other two companies cannot hope to start manufacturing until nearly the middle of 1942.

Pending completion of these projects, the only possible way to increase output is by more extensive subcontracting. Allison is already having many parts produced by the Cadillac plant; and Pratt & Whitney is said to be subcontracting more than half its requirements for parts. Wright, on the other hand, has been much more conservative.[90]

Meanwhile, a shortage of propellers has been reported, despite the fact that propeller manufacturers during 1940 increased their productive floor space from 393,240 to 845,800 square feet.[91] Here, too, expansion projects which are now under way with government assistance may ultimately eliminate the bottleneck. United Aircraft is converting and equipping an old plant in Connecticut for the manufacture of propellers; and the propeller division of the Curtiss-Wright Corporation is erecting a modern plant totaling 380,000 square feet at Caldwell, N. J., and acquiring additional facilities at Pittsburgh and Indianapolis.

Although plane production, so far, has been behind schedule, the industry expects that present bottlenecks will be overcome in time to reach a goal of 30,000 planes a year by the middle of 1942. Concentration of the industry's attention on expansion of facilities has in itself tended temporarily to retard progress in actual output. Moreover, the modern types now being put into production appear, on the whole, superior to similar German craft.[92] While Germany may develop still better models, it would have to go through a lengthy process of retooling in order to manufacture them on a considerable scale.

89. *Ibid.*, December 10, 1940 and January 7, 1941. The Cincinnati plant will raise Wright's manufacturing space for engines from 2,842,000 to 4,962,000 square feet.

90. *Business Week*, January 18, 1941, p. 32.

91. Statement by Col. John H. Jouett, January 28, 1941, cited.

THE AUTOMOBILE INDUSTRY

In recent months the tendency to call on the automobile industry for assistance in solving the problem of mass production of planes has increased. Official, as well as unofficial, plans have been advanced to gear the automotive industry into the aircraft procurement program. The most imaginative and striking proposal was made in December 1940 by Walter P. Reuther, director of the General Motors Department of the United Automobile Workers of America, who declared that the automobile industry could be mobilized to turn out 500 fighting planes a day, provided the manufacturers and the government would agree to the following measures:

1. Distribution of automobile production, normally concentrated in a few months, over the entire year, thus releasing about half the available machinery and equipment for the manufacture of planes.
2. Adaptation of automobile motor machinery for the manufacture of plane engines by adding new tools, jigs and fixtures.
3. Utilization of idle metal-stamping equipment in body and parts plants to stamp out fuselages and wings after providing new dies.
4. Employment of tool and die workers, ordinarily engaged in retooling automobile plants for new models, to build the dies, tools, jigs and fixtures needed for the manufacture of planes.
5. Utilization of idle floor space, and construction of cheap hangars for sub-assemblies and assemblies.[93]

Although the plan was widely hailed for its constructive suggestions, it has been subjected to severe criticism on several counts. It is said to minimize unduly the great differences in manufacture of planes and automobiles, and to underrate the difficulty and time involved in adapting the machinery of the automotive industry for aircraft production. Critics also maintain that even if these

92. This is true of the latest American bombers, particularly of the four-motored Boeing B-17 and the Consolidated B-24, and of the latest fighting planes, which are superior in performance and capable of 360 to 380 miles an hour as compared with 345 to 365 miles for the newer German models. There are still serious deficiencies, however, in the production of armor, armament and bullet-proof fuel tanks.

93. Summarized from plan of the United Automobile Workers of America.

features were practicable, it would still be physically impossible to step up the output of aluminum and magnesium sufficiently to meet requirements for so many planes, or to furnish sufficient armament.[94] At present the plan is under consideration by the experts on the Defense Commission.

Before the Reuther plan appeared, efforts were already under way to utilize, on a more modest scale, the capacity of the automobile industry for production of aircraft parts. On October 25, 1940, following an appeal by Mr. Knudsen for assistance in the production of bombers, the Automobile Manufacturers Association set up an Automotive Committee for Air Defense, which has worked with the Defense Commission in familiarizing the industry with the problems involved in the manufacture of airplane parts, and in surveying its facilities for press and die work, as well as forgings, for aircraft.[95] The committee's task has not been easy. It has had to overcome the initial reluctance of the aircraft industry to cooperate with the automobile manufacturers in a joint program. Time has been needed to furnish the automotive industry with detailed production designs and specifications, and problems of tooling have had to be considered.

The government and the automobile industry have finally worked out a project whereby the three biggest manufacturers — General Motors, Ford and Chrysler—will make parts for bombing planes, to be assembled in four new plants located at Fort Worth, Texas; Tulsa, Okla.; Kansas City, Mo.; and Omaha, Neb. Under this plan Ford will manufacture parts for 1,200 four-engined bombers a year, while Chrysler and General Motors will each contribute parts for 1,200 two-motor bombers. The assembly plants will be financed by the government, and operated by Consolidated, Douglas, Martin and North American Aviation.[96] The program calls for manufacture of parts for air frames only, because these require the fewest changes in equipment of the automotive industry. Production of parts is expected to start soon, and assembly operations in the fall of 1941. In the meantime, Douglas Aircraft has placed substantial orders for bomber sub-assemblies with the Murray Corporation of America and the Briggs Manufacturing Company, two automobile body plants.[97] Briggs is building a new factory for this purpose.

94. Cf. letter of John H. Jouett, *The New York Times*, January 27, 1941.

95. Statement by C. C. Carlton, Director of the Committee, *The Iron Age*, December 19, 1940.

96. Interview with Dr. George J. Mead, aircraft production expert of the Defense Commission. *The New York Times*, January 11, 1940.

97. *Ibid.*

The automotive industry is also devoting its production talent and part of its equipment to other items in the defense program. It is carrying out large orders for trucks, about 39,000 of which were scheduled for delivery by the beginning of 1941. It has also received contracts for scout cars, shell cases, fuses, bomb parts, cartridge cases, fire-control equipment, and jigs and tools. General Motors is turning out Diesel motors for submarines and other naval units, while Packard is expanding its facilities to manufacture engines for the navy's motor torpedo boats. In September Chrysler started construction of a $20,000,000 arsenal which, beginning in August 1941, is expected to turn out ten 25-ton tanks in a two-shift day. At approximately the same time, General Motors began equipping four of its plants for the manufacture of machine guns early in 1942. Altogether, the automobile industry is carrying out defense orders amounting to more than $1,400,000,000; and it is expected that these contracts will require a labor force of about 150,000 men by the fall of 1941.[98]

Ultimately, the automobile industry may be asked for a passive contribution to the armament program—namely to curtail production of cars so that valuable raw materials, tools and labor may be released for more essential products. The industry is a large consumer of the raw materials in which shortages either have already been evident or may develop. In 1939, for example, it absorbed 80 per cent of the rubber consumed in this country, 18.1 per cent of the steel, 9.7 per cent of the aluminum, 13.7 per cent of the copper, 11.4 per cent of the tin, 34.2 per cent of the lead, 12.1 per cent of the zinc, and 23 per cent of the nickel.[99] It would be impossible, however, simply to close the auto plants, or to convert them for other purposes, since continued production of trucks is essential. Even the manufacture of passenger cars could not be entirely stopped, for in many cases factory shifts and office forces could not be assembled without the use of private cars.[100] While the industry hopes to maintain normal production as long as possible, it realizes that the growing volume of defense work will in the end necessitate some restriction in the output of passenger automobiles and trucks for civilian use. Manufacturers have already agreed not to make extensive changes in models this year; and they have been working on plans to eliminate substantial quantities of especially scarce metals from some automobile parts.

98. *Business Week*, January 25, 1941, p. 13.

99. *Automobile Facts and Figures 1940*, p. 73.

100. "U.S. Gears Working Efficiency to Motors," *Automobile Facts*, October 1940.

THE SHIPBUILDING INDUSTRY

Shipbuilding is another industry which has been greatly overtaxed by the defense program. When the project for a two-ocean navy was approved in the summer of 1940, shipyards were already virtually booked to capacity. Since that time the shipbuilding industry has been required not only to undertake a huge volume of naval construction, but to build a large number of freighters for the United States and Britain.

During recent years the industry, which had languished since the close of the World War, has staged a remarkable recovery, thanks to the merchant marine replacement program launched in 1938 by the Maritime Commission and to a gradual increase in naval orders. In 1940 private yards completed 68 merchant vessels aggregating 836,440 tons, and 18 naval ships totaling 63,080 displacement tons.[101] During the same year, they received additional orders for 95 merchant ships with a total gross tonnage of 836,440, and 284 naval vessels with a displacement tonnage of 1,454,375. Since shipyard facilities had not been measurably expanded up to the middle of 1940, it was impossible to start immediate construction. The keels of only 21 of the naval vessels contracted for during the year had been laid by December 1, 1940; and by December 21 only 69 of the 513 naval ships ordered were actually on the ways.[102] Moreover, of the 34 vessels for which the Maritime Commission placed contracts in 1940, no keels at all were laid by the end of the year.[103] All the suitable private shipbuilding ways, which numbered 83 at the beginning of 1940,[104] have been constantly occupied. The same has been true of government yards.

Aware of the emergency, the Navy Department in 1940 obtained $150,000,000 from Congress to finance expansion of shipbuilding yards. By the end of the year it had entered into contracts totaling $101,195,500 for additional facilities at private yards.[105] It had encouraged two new shipyards to participate in naval construction,[106] and helped to reopen the yards of the old Cramp Shipbuilding Company in Philadelphia. In January Congress approved a bill providing $315,000,000 more for "essential equipment and facilities at either private or naval establishments."[107] From six to twelve months may be required, however, for the construction of ways, or entirely new shipyards, and the procurement of the necessary machinery. For example, the complete reconditioning and expansion of the Cramp shipyards, undertaken in November 1940, will not be finished until the end of 1941, although the keel of the first cruiser may be laid by August.[108]

Meanwhile, the shortage of shipbuilding facilities has been partly met by reducing the time required to build naval vessels. Thus the construction time for cruisers has been cut from 40 to 35 months, of submarines from 30 to 24 months, and of destroyers by three months. Plans have been made for subcontracting a larger part of the work, so that navigating equipment, engine assemblies, boilers and auxiliary machinery will arrive at yards ready for installation.[109]

The demand for rapid expansion of merchant marine construction has necessitated sweeping measures similar to those taken during the first World War. At that time the government financed the building of four huge yards which merely "assembled" ships from parts fabricated in hundreds of inland shops and factories. These yards, of which the most famous was at Hog Island, Philadelphia, had a total of 94 building-ways, and were equipped to construct more tonnage than was ever produced in any country before 1918.[110] The 60 vessels for which the British government placed an initial order in December 1940, and the 200 merchant ships included in the emergency program announced by the President on January 3, 1941, will all be built according to similar principles. The British vessels will be constructed in two new yards by the Todd Shipyards Corporation; and the American freighters will be built in seven new, government-owned yards, provided with 51 ways and operated by private shipbuilding companies.[111] President Roosevelt has allocated $36,590,000 for this purpose and asked Congress, in a special mes-

101. The comparative figures for 1939 are: 28 commercial vessels, 251,900 gross tons; 16 naval vessels, 32,740 displacement tons. Ships of 1,000 tons and over are included. Cf. statement released January 2, 1941 by National Council of American Shipbuilders.

102. *Marine Engineering and Shipping Review*, January 1941, pp. 47, 49-50.

103. U.S. Maritime Commission, *Vessels Completed and Under Construction, Report of Progress as of December 31st, 1940* (Mimeographed, January 1, 1941).

104. In addition, there were 17 ways on the Great Lakes, and 40 partially dismantled ways which could be reconditioned. National Council of American Shipbuilders, *Annual Report*, April 1, 1940.

105. Compiled from figures in *Defense*, January 14, 1941, pp. 14-15.

106. The Gulf Shipbuilding Corporation of Chickasaw, Ala., and the Consolidated Shipbuilding Corporation at Orange, Texas.

107. 77th Congress, 1st Session, *H.R. 1437*.

108. *The New York Times*, November 30, 1940.

109. National Defense Advisory Commission, *Press Release 293*, December 6, 1940.

110. E. N. Hurley, *The Bridge to France* (Philadelphia, Pa., J. B. Lippincott Company, 1927), p. 77.

111. The new yards will be built at Portland (Ore.), Los Angeles, New Orleans, Mobile, Houston, Wilmington (N.C.), and Baltimore. Contracts for five yards with 32 ways have already been placed. *The New York Times*, January 14, 19, February 7, 1941.

sage of January 16, for an immediate appropriation of $313,500,000 to defray the cost of construction.[112] The American ships, like the British, will be freighters of about 7,500 gross tons, all built according to an extremely simple, standardized design. In contrast to the Maritime Commission's other new freighters, which are capable of speeds between 14 and 19 knots, these ships will be able to do not more than 10 or 11 knots. They are intended to offset wartime losses in the world's merchant marine, and to replace the faster American ships which are being commandeered in increasing numbers to serve as naval auxiliaries. They will be built largely from pre-fabricated parts, so that construction will add as little as possible to the demand for shipyard labor which is already becoming scarce.

The projected installation of old types of boilers and engines in the "emergency freighters" throws into sharp relief one of the major bottlenecks in the shipbuilding industry—the supply of modern, efficient propulsion machinery. The construction of large steam-turbines for ships and power plants is difficult and time-consuming. The three companies which handle virtually all of this business—General Electric, Westinghouse, and Allis-Chalmers—are booked to capacity and have a large backlog of orders. Both Westinghouse and General Electric are expanding production. Westinghouse is spending $9,500,000 for additional facilities at its Lester, Pa., plant; and General Electric is devoting about $11,500,000 to expansion of its existing works and the erection of a new turbo-supercharger plant.[113] These projects are designed to supply solely the needs of the navy. Progress in the naval construction program, however, will also depend on successful and speedy execution of current plans to increase production of armor plate, guns and fire-control equipment.

THE CHEMICAL INDUSTRY

Production of chemicals, like that of iron and steel, constitutes one of the basic industries in a wartime as well as a peacetime economy. It performs a direct service to national defense by furnishing the materials and facilities for making explosives, gases and gas masks. Its indirect value, however, is perhaps still greater, for countless industrial processes are dependent on chemical products. Chemicals aid in the production of iron and steel, glass, pulp and paper, rubber and textiles, in the refining of petroleum and the recovery of metals from ores. The chemical industry turns out an amazing variety of finished products, ranging from dyes, paints, resins and plastics to fertilizers, soap, perfumes and medicinals.

The chemical industry today is much better prepared than it was in 1914. At the beginning of the first World War the industry was in its infancy. The total value of its output then was about a sixth of what it is now. The United States had virtually no dye industry and produced only very small quantities of organic medicinals, potash and nitrates. It imported 90 per cent of its consumption of dyes, as well as 90 per cent of the coal-tar intermediates needed as raw materials for its small domestic output.[114] By 1939, however, imports of dyes had declined to less than 5 per cent of consumption and those of intermediates to less than one per cent.[115] This country can now produce adequate quantities of drugs and medicinals, and is able to furnish its own chemical apparatus. In the past decade the chemical industry, in contrast to many others, has continued its rapid development. Its physical output in 1937 was 72 per cent higher than in 1929,[116] and in the last two years many new chemical plants have been erected.[117] Exports of chemicals far exceed imports. Moreover, the United States, by spending more money on chemical research than any other country, has kept well abreast of scientific and technical progress.[118]

From the point of view of national defense, nevertheless, the chemical industry has a number of deficiencies. Its facilities for the manufacture of explosives are so limited that the government has been compelled to finance the construction of new plants. Three general types of explosives are necessary in war:[119]

1. *High explosives*—used as bursting charges in projectiles, explosive grenades, mines, torpedoes and demolition bombs. The most important of these are TNT (trinitrotoluene); DNT (dinitrotoluene); ama-

112. *Ibid.*, January 17, 1941. Congress completed action on this bill and sent it to the White House for approval on February 5, 1941.

113. *Pacific Marine Review*, November 1940, pp. 47, 54; also *Business Week*, January 11, 1941, p. 44.

114. U.S. Tariff Commission, *Dyes and other Synthetic Organic Chemicals in the United States, 1936* (Report No. 125, 2nd series), p. 1.

115. U.S. Tariff Commission, *Synthetic Organic Chemicals: United States Production and Sales 1939* (Report No. 140, 2nd series).

116. Fabricant, *The Output of Manufacturing Industries, 1899-1937*, cited, p. 220.

117. According to the F. W. Dodge Corporation, the construction index of the chemical industry for the first nine months of the year rose from 100 in 1938, to 161 in 1939, and 332 in 1940.

118. F. A. Hessel, M. S. Hessel and Wellford Martin, *Chemistry and Warfare* (New York, Hastings House, 1940), p. 134.

119. Cf. *Chemical and Metallurgical Engineering*, November 1940, pp. 744-45; also Lt. Col. Earl McFarland, *Textbook of Ordnance and Gunnery* (New York, J. Wiley & Sons, 1929), chap. I; and *Naval Ordnance* (Annapolis, United States Naval Institute, 1937), chap. II.

tol (a mixture of TNT and ammonium nitrate); and ammonium picrate (explosive D, used in armor-piercing projectiles because of its relative insensitiveness).

2. *Propellants,* which expel projectiles from guns. Smokeless powder is used for this purpose by the United States, and cordite by the British. Black powder serves as an igniter of smokeless powder.

3. *Detonators and boosters*—extremely sensitive explosives which precipitate the explosion of the main bursting charge. They may be further classified into primary detonators such as mercury fulminate and lead azide, and boosters which act as "intermediaries" in the train of explosives from the detonator to the main charge. Among the boosters most commonly used in the United States are tetryl, picric acid and crystalline TNT.

The present annual production of smokeless powder amounts to only 30,000,000 pounds as compared with a 1918 output of 513,000,000 and probable requirements of 800,000,000 pounds.[120] Two government-owned plants, costing about $109,000,000 are now under construction—one at Charlestown, Ind., by du Pont, and the other at Radford, Va., by the Hercules Powder Company. The Charlestown works will start producing about 35,000,000 pounds a year in June 1941 and gradually develop an ultimate capacity of 210,000,000 pounds, while the Radford plant will probably begin operations toward the end of 1941 at an annual capacity of 105,000,000 pounds. On January 24, 1941 du Pont was awarded a $47,997,000 contract for another plant at Childersburg, Alabama. The same company received a contract early in the month to build an addition to the naval powder factory at Indianhead, Md.[120a]

The output of TNT in 1940 was only about 10,000,000 pounds, although wartime requirements may run as high as 600,000,000.[121] One TNT, DNT and tetryl plant is being erected at Wilmington, Ill., at a cost of about $30,863,000, and may start production in the last quarter of 1941. A smaller TNT and DNT plant, costing $11,325,000 and located at Weldon Springs, Mo., may be ready about the same time. A contract for a third TNT plant, at Sandusky, Ohio, was awarded last December.

The supply of raw materials for these explosives is also inadequate in several respects. All explosives are nitrogen compounds, produced by "nitrating" certain materials with nitric acid mixed with sulphuric acid. War therefore brings a sharp increase in the demand for nitric acid, which itself is derived from either sodium nitrate or ammonia. Almost all the natural nitrate, which is imported from Chile, is required for fertilizers; and the amount of ammonia which accrues as a by-product of coke ovens is far from sufficient to supply the demand for explosives. As a result, reliance must be placed on synthetic processes. At present there are only two large synthetic ammonia plants operating in this country—one at Hopewell, Va. (Solvay Process Company), the other at Belle, W. Va. (du Pont). Total production of synthetic ammonia in 1940 amounted to 260,000 tons (nitrogen content) to which must be added 159,900 tons of by-product ammonia. Experts believe that capacity must be doubled to take care of wartime requirements.[122] For this reason the army has awarded contracts for two additional synthetic ammonia works—one to du Pont on November 30, 1940, and another to the Solvay Process Company on January 2, 1941. In addition, $6,500,000 was allocated to the TVA in December 1940 for reconditioning of the nitrate plant at Muscle Shoals and construction of a new ammonia plant. Up to the present no extensive measures have been taken to expand facilities for production of sulphuric acid, even though present capacity, particularly for high-grade acid, appears inadequate for war needs.[123] It may prove relatively easy, however, to increase output within a short time.

Questions have also been raised about the supply of toluol, the basic ingredient of TNT and DNT, and phenol or carbolic acid, which is required for making the picric acid employed in explosives and chloropicrin, a war gas. Both are by-products of the coke oven, so that the supply fluctuates with the production of pig iron and gas coke. At the beginning of the last war a serious shortage of toluol was experienced. The demand was finally met by shifting from beehive to by-product coke ovens, and by erecting plants for extracting toluol from domestic heating and illuminating gas, and petroleum.[124] Today the supply would appear ample, since current annual output — about 25,000,000 gallons — is over 10,000,-

120. *Chemical and Metallurgical Engineering,* November 1940, pp. 752-53.

120a. Du Pont has also built a powder factory and is now constructing a DNT and TNT plant for the British government. *The New York Times,* February 10, 1941.

121. *Ibid.* This estimate is based on the assumption that one pound of high explosives a day will be needed for each man in our army of 2,000,000, and that 80 per cent of these explosives will consist of TNT.

122. *Ibid.;* also J. E. Zanetti, "Nitrogen Self-Sufficiency," *Industrial and Engineering Chemistry,* September 1940; and "Nitrogen and the New Preparedness," *News Edition* (American Chemical Society), June 25, 1940.

123. An article in *Chemical and Metallurgical Engineering* (November 1940) puts total defense needs for sulphuric acid at 12,000,000 tons (50° acid), as compared with an estimated output of 9,400,000 tons in 1940. Over a third of this was produced by the so-called "chamber-process," which yields an acid requiring further concentration before it can be used in the making of explosives.

124. "Petroleum Toluol for National Defense," *Chemical and Metallurgical Engineering,* August 1940.

000 gallons higher than in 1918. Meanwhile, however, many industrial uses of toluol have developed, so that only part of the present supply could be diverted to explosives. Although coke ovens could probably increase their output to over 30,000,000 gallons,[125] this total would still fall far short of wartime demands. The deficiency can undoubtedly be met from petroleum, provided the necessary plants are built for this purpose. The Shell Oil Company recently finished a small plant at Houston, Texas, which will produce about 2,000,000 gallons a year and will be ready to increase its capacity to 7,000,000 gallons. In October 1940 the War Department also contracted with the Humble Oil and Refining Company to build a government-owned toluol plant at Baytown, Texas, which will have many times the capacity of the Shell refinery.

Production of phenol, which amounted to about 70,000,000 pounds in 1940, has risen sharply in recent years because it is used extensively in making synthetic resins and plastics. The supply derived from distilling coal tar is being supplemented by synthetic production from benzene, another coke oven by-product. A new synthetic phenol plant, with an annual capacity of 15,000,000 pounds, was completed in November 1940.[126] Others may be required.

On the whole, present deficiencies of the chemical industry are minor compared with those before the first World War. The steps now being taken will go far toward preparing the industry for the tasks assigned to it under the national defense program.

CONCLUSION

Measured by actual output, the defense program appears to be making rather slow progress. While Germany is turning out about 3,000 planes a month, the production rate in the United States has just passed 900. Of this number, only a little over 500 have been combat planes, and these must be divided between the British and American air forces. Production of bombers, in particular, is lagging. Aircraft engine and propeller manufacturers have been unable to keep pace with the output of fuselages; and shortages of aluminum and magnesium have here and there delayed production. Although the manufacture of light arms, such as the Garand semi-automatic rifle, is making good progress, production of modern ordnance is less satisfactory, owing in part to constant changes in types necessitated by the war. Heavy forging and heat-treating facilities constitute serious bottlenecks. In January this country turned out only 20-odd light tanks; although officials had previously given the impression that the rate was 4 a day, or 100 a month. There is a shortage of light armor plate for planes, tanks and naval vessels, and of heavy armor for battleships. Government and private shipyards are so overloaded with naval and merchant marine construction, that the keels of only a few of the hundreds of ships ordered in 1940 have actually been laid. In many instances, plants and factories are anxiously awaiting deliveries of machine tools, without which they cannot start or expand production.

ACCOMPLISHMENTS. These aspects of the defense program, however, should not obscure the fact that very real progress is being made in the establishment of a vast munitions industry. The creation of such an industry is inevitably time-consuming. Before this country could begin production on a large scale, it was necessary to determine the requirements of the defense program, draw up designs and specifications,[127] provide machinery, build plants, train additional labor, and educate technical and managerial staffs in many hitherto unfamiliar tasks. Even Hitler, with all the power at his command, took five years to equip his army and air force and gird the Third Reich for war. The United States cannot be expected to attain this goal within six months or a year, although our tremendous natural wealth and industrial resources should enable us to arm more speedily than Germany, provided there is the requisite planning, organization and singleness of purpose.

At present this country is in the throes of a great industrial expansion. Government and industry are spending more than $1,500,000,000 merely to create the plants, equipment and machinery needed for defense production. Industrialists have been so preoccupied in building up productive capacity that progress in current output has been retarded to some extent. In 1941 and early 1942 these expansion programs will begin to bear fruit, and production during the latter half of 1941 should be many times what it is today. The aircraft industry is expected to more than double its output before the end of the year; and there is reason to believe that it may yet be able to manufacture 30,000 planes annually by the middle of 1942. Packard and Ford will begin to help out in the building of plane engines by the summer of 1941, and at that time the companies already making motors for combat planes expect to turn out twice

125. *Ibid.*, p. 529.

126. *News Edition* (American Chemical Society), November 10, 1940, p. 921.

127. Ordinarily two or more years are required between the designing of a piece of ordnance and its actual construction. *The New York Times*, December 11, 1940; also H. W. Baldwin, *ibid.*, December 16, 1940.

as many as today. In another half-year also, Chrysler will have completed its arsenal which is expected to manufacture 10 medium tanks in a two-shift day. Shipbuilding facilities are at last undergoing rapid expansion. New yards are being laid out, and many shipbuilding ways are being added. In almost every field, government and industry have taken, or are taking, steps to eliminate actual and potential bottlenecks in production. At the end of the current year the United States may in fact be able to live up to its rôle as a great "arsenal of democracy."

THE OPM. The Office of Production Management, which President Roosevelt formally established on January 7, 1941, should prove an effective agency in organizing the country's economic life for defense. The National Defense Advisory Commission, on which it is superimposed, had been subjected to severe criticism on two counts; first, that it was purely advisory and thus without real authority; and second, that it had no chairman, other than the President, who was extremely busy with many other tasks. These defects have now been largely overcome. The Office of Production Management—or OPM, as it is called—has been granted wide authority to take all "needful and appropriate" measures to increase production of war materials and coordinate activities of all governmental agencies dealing with this problem. In particular, the President conferred on the OPM his authority to determine "when, to what extent, and in what manner" priorities shall be accorded to deliveries of war material, and to commandeer factories and place mandatory orders whenever private management proves unwilling to cooperate.[128] The President failed, however, to transfer the actual procurement of war materials from the War and Navy Departments to the OPM—a step which many critics of the existing defense organization have long advocated. Its powers, nevertheless, are much broader and more specific than those Mr. Baruch enjoyed as head of the War Industries Board during the last war. While the President declined to vest authority over economic mobilization in a single person, who might be biased in favor of either labor or capital, he centralized it in a group of four men, with Mr. Knudsen as director, Mr. Hillman as co-director, and the Secretaries of War and the Navy as the other members. If Mr. Knudsen and Mr. Hillman work well together, this team of labor and management may inspire more general confidence and support than one-man control. If not, a super-coordinator may have to be appointed.

128. For the text of the President's Executive Order establishing the OPM, cf. *Defense*, January 14, 1941, p. 3.

THE CONTROVERSY OVER EXPANSION. The OPM must resolve many difficult questions before the country's industries can be completely mobilized for defense. A crucial difference of opinion on the basic approach to defense production still prevails in Washington. While there is general agreement on the necessity for new or additional capacity to manufacture those items in the munitions program for which production facilities have been lacking or deficient in the past, the need to expand industries which can produce both materials for war and goods for peacetime consumption is seriously disputed. In these industries it is possible to satisfy defense demand either by adding new plant and equipment, or by curtailing production for non-essential civilian needs. One school of thought, generally identified with the New Deal, believes every effort should be made to increase productive capacity on a scale sufficient to satisfy all conceivable war requirements and, at the same time, to maintain, or even raise, living standards. This school sees in the defense program an unusual opportunity to obtain full utilization of all idle man power and resources, with ultimate benefit to the people at large. Mr. Leon Henderson, a member of the Defense Commission, has declared that "the country should be thinking about ways of knocking the ceiling off all limitations on production" instead of "curtailing civilian consumption for the sake of defense."[129] Proponents of expansion do not fear the spectre of surplus capacity after the emergency, for they are confident that the government will be able to direct and control economic life in such a way as to secure full employment of all available plant and equipment.

The second school of thought, representative of more conservative elements, opposes a general increase in industrial capacity. It recalls the sharp slump after the last war, when the country had to bear the cost of maintaining or scrapping a lot of idle plant facilities. The conservatives point out that the burden of defense orders falls most heavily on the iron and steel, machine tool, railway equipment and shipbuilding industries—the so-called capital goods industries, which suffered severely during the depression and for many years operated far below capacity. In their opinion, any attempt to expand these industries unduly in order to meet a temporarily inflated demand would create a maladjustment in our economy, which depends for its stability on a proper balance in output of consumers' and capital goods. They also fear that a substantial expansion program would impose so many demands on the country's economy as to overtax transportation facilities and the sup-

129. Cf. editorial, *New York Herald Tribune*, December 29, 1940.

ply of skilled labor and numerous materials. In general, the conservative school would have the government commandeer a larger proportion of available capacity by insisting that defense orders take priority over other business, and by limiting production of nonessential goods.

PRIORITIES. Even if this basic controversy should be settled in favor of the proponents of expansion, it is unlikely that production facilities can be increased sufficiently to avoid widespread application of priorities at the expense of normal consumption. Invocation of priorities undoubtedly creates difficult problems. If extensively used, priorities may raise the cost of living considerably, thus necessitating price control measures. The administration of priorities is extremely complicated because, to be effective, they must apply not only to government contracts, but also to subcontracts and to supplies of raw materials for defense orders. In addition, delivery schedules must be carefully synchronized, and care taken to determine the relative urgency even of government orders.

These considerations have perhaps made the government reluctant to use its priority powers. Since August 1940 the Priorities Committee of the Army and Navy Munitions Board has been assigning preferential ratings to government contracts which prime contractors were permitted to extend to their subcontracts. These ratings, however, have not been binding; and industry has been left free to carry out defense work according to its own discretion. Today, as British and American government orders continue to accumulate and production in many industries has attained capacity, definite action to enforce prior performance of defense orders has become imperative. The organization of a special priorities division in the OPM, under the direction of Edward R. Stettinius,[130] indicates that the Administration is becoming aware of this need. The shortage of aluminum, magnesium and certain other non-ferrous metals seems to necessitate immediate steps to curtail consumption for nonessential products. Mandatory priorities in the machine tool and iron and steel industries can hardly be avoided. Consumers as a whole must be prepared for an increasing measure of sacrifices in order that defense may have first claim on the country's resources.

130. The division is composed of five administrative groups covering minerals and metals, commercial aircraft, chemicals, tools and equipment, and general products. Committees, representing industrial consumers and the government, have been appointed to advise on the application of priorities in the production of steel, commercial aircraft, aluminum and magnesium, non-ferrous minerals and metals, chemicals and machine tools. *The New York Times*, January 8, February 2, 1941.

MOBILIZING IDLE CAPACITY. The need to invoke priorities may be minimized to some extent if more intensive efforts are made to mobilize all available productive capacity. Sample surveys conducted by the Labor Division of the Defense Commission, as well as local and nation-wide inventories carried out by private groups such as the National Association of Manufacturers, indicate that there is still considerable idle plant and equipment. The companies which have received prime government contracts are far outnumbered by those which have received no defense business.[131] The country now faces the necessity of redistributing the work involved in each government contract among the thousands of concerns equipped to do some, but not all, of it. This task is undoubtedly difficult. To enlist untried and inexperienced concerns as subcontractors may entail higher costs and lower quality. If new subcontractors fail to do adequate work or meet delivery schedules, production may be retarded instead of accelerated.

Nevertheless, the success of the defense program may be determined to a large extent by efforts to gear the nation's small plants and shops into production of war materials. Both the War and Navy Departments have appealed to their contractors to subcontract, or "farm out," a larger proportion of their work. Official and unofficial inventories have already done much to disclose the location, nature and extent of factories and machinery which are still partly or wholly idle. In some localities idle facilities have been pooled for the purpose of obtaining defense work. A number of local and state clearinghouses have been established for the convenience of contractors and would-be subcontractors; and the 12 Federal Reserve Banks and their 24 branch offices have been enlisted to advise small manufacturers on ways and means of obtaining a share of the defense business. Still more sweeping measures appear necessary. The reluctance of many manufacturers to subcontract part of their work must be overcome. The problem of subcontracting will have to be studied intensively in each industry. A campaign might be launched to educate small concerns, perhaps by experimental orders, in the production of articles for defense; and a hierarchy of local, state and regional clearinghouses might be created to facilitate mobilization of all industrial capacity. In the current emergency every idle man and machine detracts from the strength of the country.

131. For example, prime government contracts have gone to only 1,850 of the 8,500 metal-working establishments having an annual production in excess of $100,000. *The Iron Age*, January 30, 1941, p. 32.